World Crane Population—Existing and On Order

Size	Ship Handling	Operating in 1995	1996 - 1998 Deliveries*	U.S. /Canadian Orders 1996 - 1998
Panamax (<144' outreach)	13 wide 32.2m beam <4000 TEU	77%	30%	7
Post Panamax (144' - 150' outreach)	16 wide 40.0m beam 4000-6000 TEUS	19%	23%	4
Beyond-Post Panamax (>150' outreach)	17 wide + 42.5m + beam 6000 TEU +	3%	44%	55

* A total investment of $1.2 billion dollars.

Source: Containerisation International, AAPA and P&O Containers

offloads/onloads a relatively low percentage of its cargo at each port. With larger ships, fewer calls would be made and a larger percentage of cargo would be offloaded/onloaded at each port. A single-call service to a major hub might involve offloading and onloading 85% of vessel capacity (with 15% assumed as a typical factor for empty slots).

If a 5,000 TEU vessel makes one U.S. call, 8,500 TEUs would be handled (using an 85% load factor). With an assumed BPP crane productivity of 25 lifts per hour (45 TEUs), a total of 189 crane-hours would be needed. With four cranes working the ship, time working at berth would be 47 hours, which is longer than most current container ship calls. Adding cranes reduces working time (38 hours with five cranes and 32 hours with six cranes), but these times are still longer than current one-day turnarounds. These figures would be reduced, of course, if the vessel made two or more North American calls and loaded/unloaded a smaller percent of its capacity at each.

Container Storage Requirements

How much container storage is needed to serve each vessel berth? Historically, the ratio of container storage to berths has increased as vessel size has increased. This is due to the disconnect between wharf activity (rapid, around-the-clock transfer when vessels are at berth) and gate activity (more regular, 8-hour-a-day vehicle movements). Terminal storage serves as an intermediary between these two flows, with "dwell time" (the amount of time a box spends stored in the terminal) as the key variable. As larger vessels are unloaded more rapidly and the disconnect between land and water flow rates becomes greater, larger terminal storage areas become necessary.

Operationally, there are a number of things a terminal can do to reduce the amount of storage required (denser stacking, longer operating hours, use of ITS technologies, on-dock rail, etc.). If, however, it is assumed that terminals continue to operate more or less as they do presently, then container storage requirements per vessel berth would increase as a function of vessel size. The generally accepted ratio for state-of-the-art terminals for Post-Panamax vessels is 50 acres per berth. With design vessel sizes increasing by nearly 50%, it may be appropriate to increase the storage requirements by a similar factor, to 75 acres per berth. More research and simulation modeling will be needed to fine tune this number.

MEGASHIP TERMINAL DESIGN PARAMETERS

With this information, it is possible to begin to define parameters for an optimized megaship terminal. It could have the following physical characteristics:

—Minimum of 2,500 linear feet of berthing (two megaship berths @ 1,250 feet each).

—Up to 3,000 linear feet of berthing (three Post-Panamax berths @ 1,000 feet each) to accommodate a mix of vessels.

—50 foot water depths at berth.

—High berth occupancy rates (50% target). With two berths, there would be two ships 25% of the time, one ship 50% of the time, and no ships 25% of the time. Put another way, during times when vessels are at berth, 33% of the time there would be two at berth and 67% of the time there would be one at berth.

—A minimum of three Beyond Post-Panamax cranes per berth. This would result in three cranes per vessel 33% of the time and six cranes per vessel 67% of the time. The average service—five cranes per vessel—provides reasonable vessel turnaround times. However, more cranes per berth would certainly be desirable.

—Upgraded wharf load-bearing capacity for the BPP cranes.

—Up to 75 terminal acres per megaship berth or 50 acres per standard berth (150 acres for 2,500 to 3,000 linear feet of berthing).

—State-of-the-art gate complex and on-dock rail.

Such a terminal might reasonably provide a throughput of between 450,000 TEUs/year (3,000 per acre) and 900,000 TEUs/year (6,000 TEUs per acre), depending on operational factors such as storage density, working hours, use of advanced in-terminal equipment, intermodal rail utilization and degree of transshipment to/from the terminal.

New terminals on the U.S. West Coast are being designed to standards close to these. Existing terminals may need to be modified to conform to these criteria. At a minimum, they will need to meet the berth and crane standards; it is possible that operational improvements could substitute for increases in container storage area.

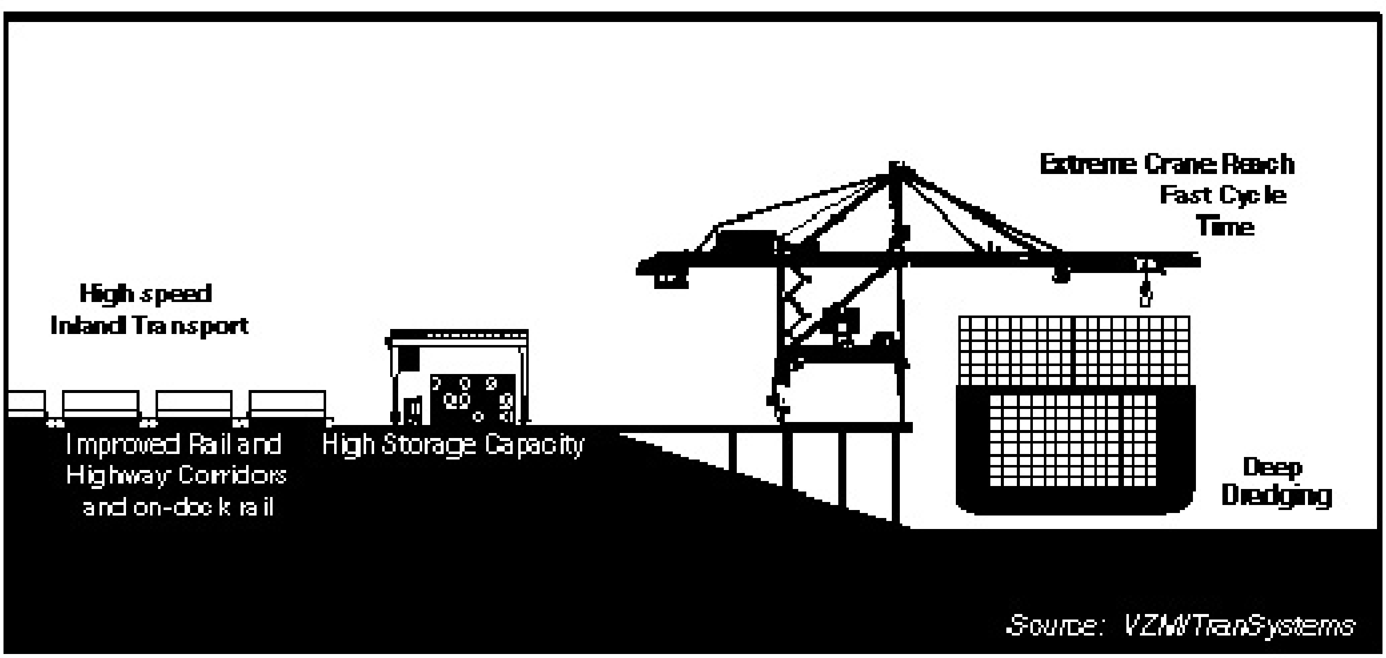
TRANSSHIPMENT TERMINALS

The terminal design parameters defined above assume an origin/destination port with very little ship-to-ship transfer. If ship-to-ship transfer is a large percentage of overall terminal throughput, the need for wharf and crane capacity is changed in direct proportion to the number of transshipped TEUs (which are counted on both inbound and outbound moves). Storage requirements change by half the number of transshipped TEUs (since there is one storage event for two wharf moves). Gate and landside access capacity is needed only for the non-transshipped TEUs. For example, let's assume a terminal with a throughput of 450,000 TEUs, of which half (225,000 TEUs) is transshipment. Looking at an idealized terminal module, two berths would still be required, but would need 25% less terminal acreage (from 150 acres down to 112 acres) and would only need gate and landside access capacity for 225,000 TEUs.

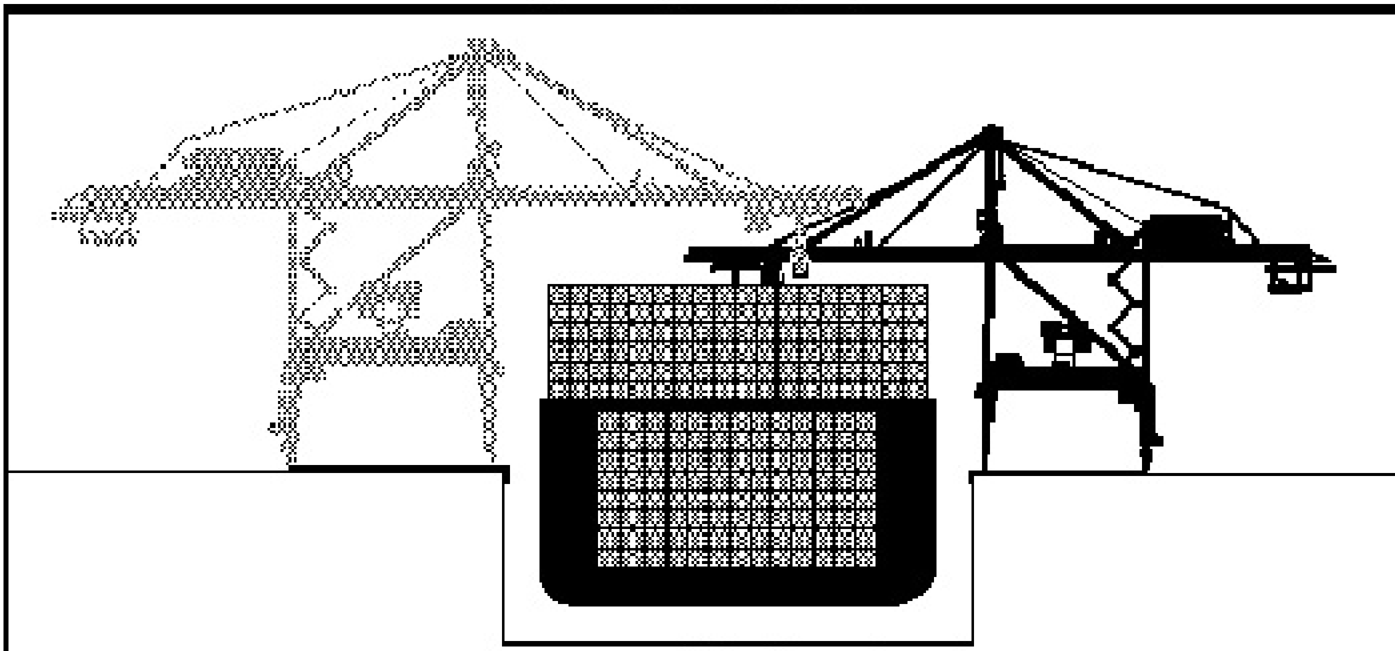
Alternatively, transshipment cargo could be handled at separate terminals specifically designed for that purpose. A 450,000 TEU/year transshipment terminal might have 2,500 linear feet of berthing (two megaship berths @1,250 feet each), an area of 75 acres and a very small gate. This terminal would be only 1,300 feet deep—about half the depth of a non-transshipment terminal.

Another way to handle transshipment is through "midstream" terminals. These are water areas in which a barge-mounted crane can be positioned between two vessels. The crane lifts the box off one vessel and onto another, possibly with an interim point of rest on the barge. The advantage of this operation is that it requires no land area; the disadvantages are that the barge-mounted cranes are slower than shoreside cranes, there is little room for interim storage/repositioning of boxes, and both vessels must be in the

Mega-Ships Require Specialized Ports With High Infrastructure Investment



Loading Strategy Using Finger Piers



Source: Morris Cranes and P&O Containers

same place at the same time. This is not theory—it is estimated that about 30% of Hong Kong's transshipment is handled this way, and New Orleans is also doing midstream transshipment.

A different design strategy for a transshipment terminal uses a finger pier with container cranes on each side and storage in the center. This allows vessels to berth on either side, and at different times or simultaneously. This strategy is currently being used in Singapore.

LANDSIDE ACCESS

The landside access systems serving U.S. ports have been evolving as rapidly as vessel design. In particular, the rapid rise of intermodal rail service has had a huge impact by facilitating the development of landbridge services. As much as 40% of West Coast international containers are handled by intermodal rail; this figure is lower elsewhere (generally between 10 and 25%) but appears to be rising. Three key trends are: the growing importance of intermodal rail; the continuing importance of truck access; and the degree to which effective landside access can "decouple" port locations from the metropolitan market areas they serve.

Intermodal Rail Impacts

As carriers concentrate at selected hub ports, more hinterland and coastal origins and destinations will fall outside of a 400-600 mile radius from the ports that serve them. Outside this radius, rail is cost-competitive with truck, so the result should be a substantial increase in intermodal rail activity. With increased use of intermodal rail, several effects are observed:

—Trips that otherwise would require trucks can be moved by rail, resulting in environmental benefits (fewer vehicle moves and lower emissions).

—Boxes that would otherwise remain in the terminal an average of seven days or more tend to leave the terminal in around two days, freeing up storage area for other boxes and reducing the total storage acres needed.

—Intermodal rail is a key attractor for shipping lines, particularly if service by competing carriers is available, the facilities are on-dock and the lines are cleared for double-stack trains. With ocean shippers and carriers becoming more integrated into the "total trip" chain, they will increasingly choose to consolidate at ports with superior intermodal connectivity.

The recent round of rail mergers (UP/SP, BN/SF and KCRC/TMM) and the proposed division of Conrail between NS and CSX is expected to result in an improved, rationalized U.S. railroad system. The mergers also pave the way for the formation of future transcontinental partnerships between remaining carriers, and for integrated long-term partnerships between rail companies, ocean carriers and port complexes.

Post-Panamax vessels and megaships can generate extremely high box traffic. The successful megaship terminal will need to provide on-dock or near-dock rail to serve these vessels and minimize the truck traffic and environmental impacts associated with huge, rapid transfers of cargo. There will be increasing demand on existing rail infrastructure and increasing need for projects like the Alameda Consolidated Transportation Corridor to rationalize rail access to ports. Other types of rail projects that may be needed for double-stack clearance and grade crossing elimination.

There also is significant concern about the inland impacts of rail traffic generated by ports. Midwest railyards and cross-country mainlines are rapidly approaching capacity. Additional port-related intermodal traffic may trigger the need for significant improvements hundreds or even thousands of miles inland from the ports themselves.

Truck Movements

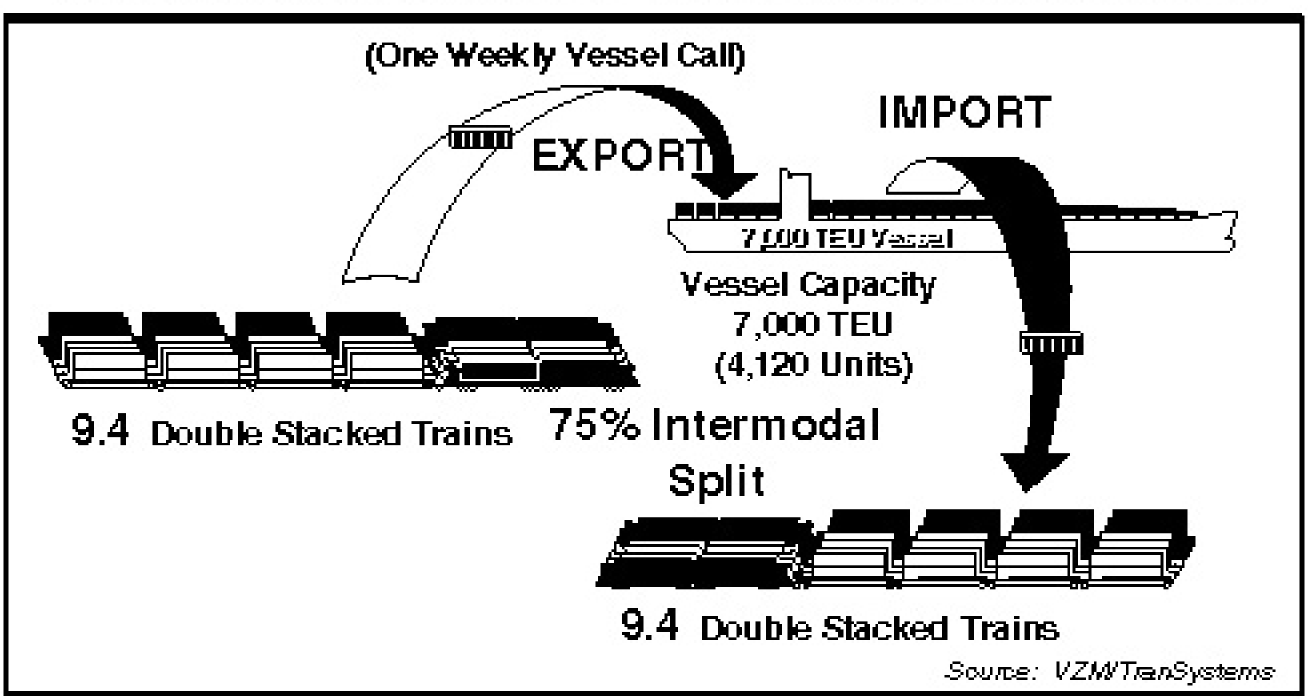
Trucks are expected to continue to carry the majority of port traffic, and the high trip generation from the megaship module illustrates that highway access will remain a critical concern. Providing safe roads, adequate travel lane and gate queuing capacity, and clear signage within ports will be critical concerns. There is also a growing understanding that freight movement is a statewide and even a multi-state issue. In fact, an ongoing study by thirteen southeastern States is looking at multi-state freight corridors to handle future port-related traffic from Latin American trade.

Truck volumes are extremely sensitive to the intermodal rail split. With throughput of between 450,000 and 900,000 TEUs per year through the gate (that is, excluding transshipment cargo) and a 40% share to on-dock rail, there might be anywhere from 1,730 to 3,460 truck trips on a typical day (assuming operation on weekdays); there might also be between 2 and 4 unit train calls per day (assuming operations through the week). With 0% to on-dock rail, there might be 2,880 to 5,770 truck trips on a typical day (5-day operation).

PORT CAPABILITIES AND PLANNED IMPROVEMENTS FOR MEGASHIP BERTHS

Historically, the water move was made up to a city dock. Now, with very expensive ships, the logistics objective shifts to minimizing vessel transit time and reducing the water move to the minimum possible. At the same time, deregulation of trucking and the rise of intermodal rail are making the landside move to "hinterland" destinations increasingly affordable. Over time, these two trends will reinforce each other. One likely effect is that ports located nearest to shipping lanes and providing superior landside access would grow fastest—with proximity to urban consumption

A 7,000 TEU Mega-Container Vessel Can Produce High Intermodal Rail Volumes



zones being of lesser importance—while ports at a distance from shipping lanes or suffering from poor landside access would see slower growth.

The future need for megaship berths in the US is difficult to measure. The DRI forecasts provide some guidance, but no conclusive answers. DRI has projected vessel calls on the basis of fully-loaded trips to and from a single U.S. port of call—an unlikely scenario in practice. Also, the vessel forecasts are "unconstrained" and assume both available capacity and a profitable market for megaship deployment. Still, working through the exercise using reasonable assumptions (25 lifts/hr, 5 cranes per berth, 33% berth occupancy, around-the-clock berth operation), the indicated need is for:

- —12 to 14 megaship berths in the Atlantic: 7 to 8 in the North Atlantic and 5 to 6 in the South Atlantic.
- —up to 23 megaship berths in the Pacific: 7 in the North Pacific and 16 in the South Pacific.
- —up to 14 megaship berths in the Gulf.

These are very crude calculations fraught with assumptions, and it do not address terminal competitiveness issues or shipper/carrier requirements, but they do suggest that there may be a substantial unmet demand for large vessel berths at U.S. ports.

Putting aside these calculations, the ultimate test of "need" for megaship berths is whether carriers can deploy them profitably. Where this market need develops, terminal infrastructure to capture it usually follows. To date, carriers have deployed megaships almost exclusively on the U.S. West Coast. However, carriers are increasingly concerned that megaship capabilities be developed on the East Coast.

Atlantic Coast Ports

There are currently no 50-foot berths at Atlantic Coast ports, and there are no plans in place to provide any. Halifax and Hampton Roads have some berths at 45 feet, and the Port of New York and New Jersey plans to go to 45 feet at Port Newark/Elizabeth.

Pacific Coast Ports

Looking at the North Pacific ports, there are five berths that provide 50 foot water depths—three in Vancouver, BC (Vanterm), one in Tacoma (Terminal 7), and one in Seattle (Terminal 46). There will be two new 50-foot berths at Vancouver, BC (at Deltaport). Seattle, Tacoma and Portland are planning terminal improvements, but none provide 50 foot berth depths. Along with the five existing 50-foot berths, this brings the North Pacific total to seven.

In the South Pacific, there are three 50-foot berths at the Long Beach Container Terminal in Long Beach. Long Beach plans to add five new 50-foot berths at Long Beach (Hanjin and the Navy Complex), while Los Angeles will have access to eight such berths (APL and Pier 400) when their main channel is deepened. Along with the three existing 50-foot berths, this will bring the South Pacific total to sixteen.

Gulf Coast Ports

There are currently no 50-foot berths at U.S. Gulf Coast ports, and there are no plans to provide any. The maximum depth is at Houston, which is dredging its Deep Ship Channel to 45 feet.

IMPLICATIONS FOR FUTURE IMPROVEMENTS

The megaship requires adjustments to current terminal designs, but not radical restructuring. Planners should consider the possibility that vessel designs may evolve to the point where terminal designs must be completely overhauled. Just as the Panamax and Post-Panamax ships made finger piers obsolete, is there a vessel design that makes today's rectangular box container terminal irrelevant?

R. G. McLellan of P+O Containers looked at this question in the context of his 15,000 "flight of fancy" containership. He concluded that such a ship would need: (1) a huge 28-wide outreach crane, or (2) to be worked on one side, then pulled out and turned around and worked from the other side, or (3) worked simultaneously from both sides while sandwiched between finger piers, forcing designers to resurrect "old fashioned" layouts abandoned as unsuitable for containerships.

The Fast Ship Terminal is a good case in point for how a radical vessel loading strategy (airlifted container trains) results in a radical terminal design. Many in the industry feel that one or more of these radical technologies—the 15,000 TEU ship, Fast Ship, the TechnoSuperLiner or something else—has a good chance of penetrating the market in the next 15 years.

PROJECTED IMPACTS ON OPERATIONS

This background section provides an overview of operational impacts associated with the deployment of megaships. There are two broad categories of impacts: system-wide operational changes in vessel logistics and deployment, to which U.S. ports must respond; and in-terminal operating strategies that U.S. ports may need to pursue to maximize productivity while minimizing capital and operational costs.

VESSEL LOGISTICS, HUB PORTS, AND VESSEL DEPLOYMENT STRATEGIES

A number of factors enter into a shipper's or carrier's decision to deploy a given vessel on a given itinerary. These include, but are not limited to: port capability and facilities, cost for utilization of port facilities, transit and turnaround time, market size at port, ability to fill the ship on backhaul, adequacy of landside connections and customer preferences. Shippers and carriers regularly adjust their services in an effort to minimize costs and maximize service and revenue.

With the high capital cost of megaships, there is a huge cost associated with transit time. It is likely that calling at multiple ports will have a higher cost (in time) than the cost (in dollars) of serving these markets with feeder ships or landside modes (truck or rail). Choice of services is also being driven by port capabilities (who can handle these vessels?), comparative facility costs (ports negotiate leases on a competitive basis), availability of landside connections, and location of major customers.

An increasingly important factor is the trend to consolidate services and assets by shippers and carriers. In the past several years, as vessel and terminal development costs have increased, there has been tremendous growth in the number of shippers and carriers joining together in consortia to share assets, maximizing
utilization and minimizing redundant investments. Together, these factors make it likely that shippers and carriers will minimize their megaship ports of call and concentrate their operations in hub ports. Services between hub ports and other ports and market areas could be provided using feeder vessels and transshipment (a "hub and spoke" system) and/or intermodal rail.

Even if hub ports gain market share relative to the non-hub ports as shippers and carriers consolidate their services, it should be emphasized once more that the non-hub ports are not "losers"—even losing market share, they are likely to grow their Panamax and Post-Panamax services, as well as gaining traffic from feeder vessel services associated with hub ports.

Atlantic Coast Ports

Atlantic port services are extremely diverse and cover the globe. Just how many "hubs" will be needed in the Atlantic, and where they will be located, will be a function of available terminal infrastructure and carrier economics. The degree and location of hubbing on the Atlantic Coast is impossible to predict at this point, but several scenarios seem plausible:

—Maximum hubbing: megaships would handle the full potential market in DRI's forecasts. Deep draft hub ports would grow substantially faster than non-hubs, with impacts on non-hub ports' market shares. Under this scenario, there could be: a) northern and southern hubs, or b) northern, central and southern hubs, or c) multiple smaller hubs (some possibly with less than 50 feet of water) in each region. Potential candidates based on water depth, current traffic and location include—but are not limited to—Halifax, New York, Hampton Roads, Charleston, Savannah, Jacksonville, Everglades/Miami, San Juan and Freeport.

—Moderate hubbing: megaships would handle substantial cargo volumes, but less than the full share of the potential market in DRI's forecasts. Deep draft hub ports would grow faster than non-hubs, but with less significant impacts on non-hub ports' market shares than in the maximum hubbing scenario. Again, there might be either a few major hubs or multiple smaller hubs. Arguments in favor of this scenario are: (a) the optimal deployment of megaships is on a limited number of high-traffic corridors, and (b) Atlantic services are generally characterized by a mix of high- traffic corridors and diverse lower-traffic services with multiple itineraries and origins/destinations. The degree to which these lower-traffic services can be profitably consolidated will in large part determine the extent of hubbing.

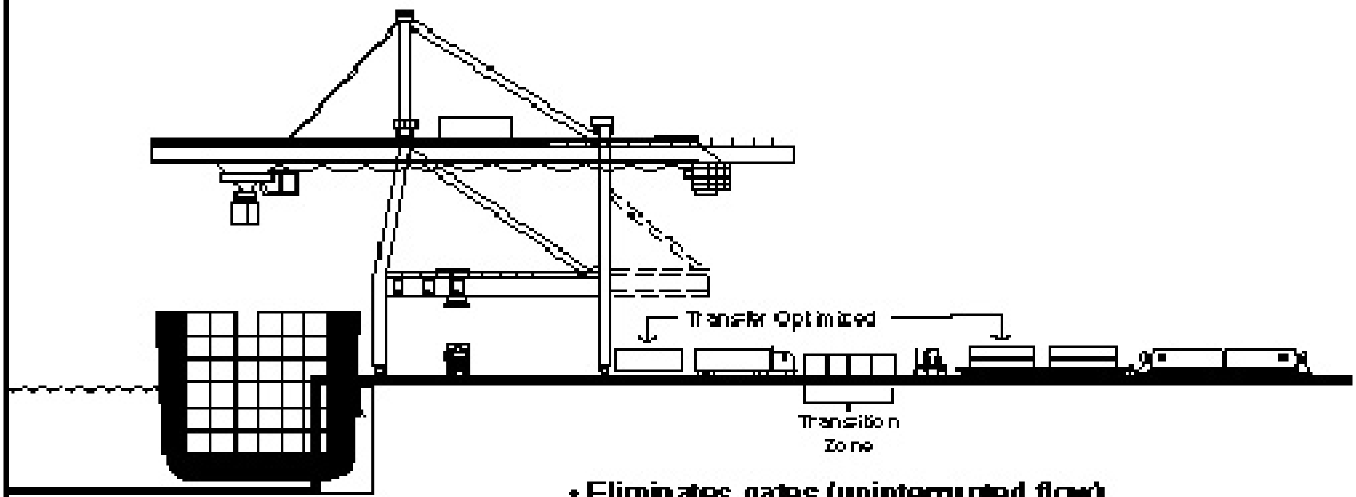
—Minimum hubbing: relatively few megaships would be deployed in the Atlantic due to port infrastructure constraints and carrier economics. These ships would be accommodated at deep-draft harbors which would grow at a faster than average rate, but other ports would not lose substantial market share since the great majority of cargo would be on vessels currently handled at these ports. This is considered the least likely scenario.

Pacific Coast Ports

"Containerisation International" identifies more than 150 principal trade routes for Pacific Coast ports. Typical itineraries for Far East-West Coast services fall into the following categories: (1) a single call at Seattle/Tacoma; (2) a call at Seattle/Tacoma with a second call at either Vancouver or Portland; (3) a single call at Los Angeles/Long Beach only; (4) a call at Los Angeles/Long Beach with a second call at Oakland; and (5) calls at both northern (Vancouver, Seattle/Tacoma, Portland) and southern (Los Angeles/Long Beach, Oakland) ports.

Megaships may be deployed on services that: (1) call at Seattle/Tacoma, with an optional second call at Vancouver, BC or Portland, and (2) call at Los Angeles/Long Beach, with an optional second call at Oakland. In this scenario, Los Angeles/Long Beach

Intermodal Interface—The Way it Could Be



- **Eliminates gates (uninterrupted flow).**
- **Reduces distance and traffic / environmental impact.**
- **Minimizes hostler movement.**
- **Minimizes rail car movement.**
- **Maximizes loading / unloading capability.**
- **(Lift Productivity)**
- **Unrestricted non-rail container flow.**

Source: Vickerman · Zachary · Miller

and Seattle/Tacoma serve as major hubs, with other ports as subsidiaries. An alternative scenario is: (3) an additional service calling at Vancouver, BC with an optional second call at Seattle/Tacoma or Portland. This scenario, with Vancouver, BC developing as a significant hub, is quite possible based on its current and planned waterside and landside assets. Another alternative scenario is: (4) an additional service calling at Oakland, with an optional call at Los Angeles/Long Beach. The development of Oakland as a significant hub port is also possible, but will require significant new investments in waterside and landside improvements.

These scenarios illustrate the possibility of between two and four major West Coast hub ports. Services between hub ports and other ports and market areas could be provided using feeder vessels and transshipment (a "hub and spoke" system) and/or intermodal rail.

Gulf Coast Ports

Origin and destination ports for Gulf Coast services involve multiple ports of call in the Gulf, and the transatlantic services typically include one or more calls at major Atlantic Coast ports as well. It is possible to envision megaship services to Europe and the Mediterranean with one call at a Gulf port and one call at a South Atlantic port. If the infrastructure is available, it is also possible to envision services to Mexico, Central America and/or South America with one call at a Gulf port and one call at a South Atlantic port, or to Africa on a similar service. Megaships might also call at two separate Gulf ports on these itineraries. More than two calls in the Gulf on the same voyage seems less likely, since megaships need to be operated with a minimum of in-port time.

IMPACT OF TRANSSHIPMENT ON PORT INFRASTRUCTURE

The degree of transshipment that each carrier chooses to employ will have a dramatic—and potentially huge—effect on the need for port infrastructure. Let's assume that 500,000 TEUs per year are moved by a given carrier from Europe to the Atlantic Coast, with 250,000 TEUs to Port A and 250,000 TEUs to Port B. If none of this cargo is transshipped, then Port A and Port B each need to accommodate 250,000 TEUs over the wharf, in storage, through the gate, and into the landside access system. Port infrastructure capable of handling 500,000 TEUs per year would be needed.

However, if the carrier adopts a strategy of consolidating its cargo onto large vessels calling at Port A, with transshipment using smaller vessels to Port B, then the demand on port infrastructure is as follows:

a) Port A handles 250,000 TEUs of destination cargo, plus 250,000 TEUs of inbound transshipment cargo, plus 250,000 TEUs of outbound transshipment cargo. Port A needs to triple its wharf and crane capacity and double its storage capacity, even through no additional cargo is moving through the gate and into the region. This would have to be accomplished by: (a) expanding existing terminals; (b) developing specialized transshipment terminals; and/or (c) using midstream ship-to-ship transfer.

b) Port B handles 250,000 TEUs of destination cargo, with no change in its throughput requirements.

Port infrastructure capable of handling 1,000,000 TEUs per year would be needed to get 500,000 TEUs of cargo to Ports A and B.

Another transshipment option is to have all 500,000 TEUs go initially to interim Port C for transshipment onto vessels bound for Port A and for Port B:

a) Port A and Port B each need to accommodate 250,000 TEUs over the wharf, in storage, through the gate, and into the landside access system.

b) Port C handles 500,000 TEUs of inbound transshipment cargo, plus 500,000 TEUs of outbound transshipment cargo.

Port infrastructure capable of handling 1,500,000 TEUs per year would be needed to get 500,000 TEUs of cargo to Ports A and B. The key point is that aggressive transshipment practices could dramatically increase demands on port infrastructure, without additional traffic at origins and destinations.

ADVANCED TECHNOLOGIES AND LABOR PRACTICES

The development of hub ports will place maximum pressure on facilities to operate at maximum efficiency. Improving the throughput per acre of U.S. terminals will allow them to handle a maximum amount of cargo with a minimum of investment. Yet on a per acre basis, terminal productivity in the U.S. lags the rest of the world. United States ports handle an average of 2,144 TEUs per acre per year, versus 8,834 per acre for Asian ports and 2,974 TEUs per year for European ports. United States ports on the West Coast do substantially better (3,567 TEUs/acre) than East Coast ports (1,281 TEUs/acre).

The best Asian ports achieve their high throughputs through a combination of factors: (1) high rates of transshipment; (2) widespread use of advanced terminal equipment; (3) very intensive storage and berth utilization; and (4) around-the-clock operations. In most respects, this makes them non-comparable with U.S. ports. If Asian ports are excluded, the best non-Asian ports are handling an average of 4,000 TEUs per acre. Rotterdam, for example, achieves 4,400 TEUs per acre. Several U.S. West Coast ports are already close to achieving this number. The question is: how can the current level of performance be raised to meet or exceed this standard?

One strategy is the use of intermodal rail. The average dwell time for an intermodal container is about two days; for a non- intermodal container, it is anywhere from six to 28 days, depending on the port. For every container that is handled intermodally, you effectively triple (at a minimum) the storage capacity of the terminal.

Another strategy is intensive stacking. Chassis storage is extremely convenient in that it allows direct pick up and delivery by truckers without manipulating the container. However, you can get four times as much storage per acre by stacking four high. The trade-off, of course, is higher capital costs (rolling tire gantry cranes, straddle carriers, "top picks," etc.) and operating costs (labor to track and handle the containers).

Terminal operating costs can be reduced by using advanced terminal equipment. For example, Sea Land is using automatic driverless "bomb carts" to handle containers in the yard. Rotterdam also uses "elephant trains" (strings of chassis pulled by a single power unit) within their terminals.

Terminal operating costs can also be reduced by using advanced information technologies (a subset of Intelligent Transportation Systems, or ITS). Many terminals have developed "paperless" systems to process gate documentation. Beyond that, other systems are generally in beginning stages of deployment. Global Positioning System tags and visual readers are being used to identify and track yard equipment and containers in storage. Other systems have been developed to automatically weigh vehicles in motion, inspect containers for damage, and automatically optimize the storage and retrieval of containers using real-time computer simulation modeling.

Customs inspection is a key issue. With larger vessels offloading at ports in as little time as possible (in the case of a 5,000 TEU vessel, perhaps 4,250 TEUs in a 32-hour period), the demand on Customs agents will be sharply increased. The application of new information technologies may be part of the necessary response.

Ultimately, the cooperative partnership between labor and management may be the most important factor in maintaining and improving the productivity of U.S. ports. It may not be possible or desirable to duplicate the management and labor practices of Asian ports, but there are lessons to be learned. One lesson is that a terminal operating 24 hours a day can handle substantially more cargo than a terminal operating 8 hours a day with a comparable level of capital investment. To date, the operating costs of such a strategy have been prohibitively high, although many ports work extended hours (and all work round-the-clock with a container ship at berth). But as ships get larger and the costs and impacts of capital improvements to serve them become increasing high, this approach may become more feasible.